



# TNRCC TECHNICAL GUIDANCE

## Municipal Solid Waste Division

### **SUBJECT: GUIDELINES FOR PREPARING A GROUND-WATER SAMPLING AND ANALYSIS PLAN (GWSAP)**

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# GUIDELINES FOR PREPARING A GROUND-WATER SAMPLING AND ANALYSIS PLAN (GWSAP)

## 1. Introduction and Purpose.

The ground-water sampling and analysis program required under TNRCC Municipal Solid Waste Management regulations in 30 TAC §330.233, which conform to EPA's RCRA Subtitle D rules, is designed to ensure that ground-water data accurately represent actual ground-water quality and can be used to reliably evaluate the ground-water conditions at a municipal solid waste landfill facility (MSWLF). The purpose of these guidelines is to provide suggestions, based on our current knowledge and published sources, for preparing an adequate ground-water sampling and analysis plan (GWSAP). These guidelines are not intended to be rules or policy and do not include all acceptable practices. Applicable sections from 30 TAC §§330.230-330.242 (Subchapter I) are included.

The GWSAP should be a stand-alone document that can be used by the sampling and analytical personnel to perform all required activities related to ground-water sampling and analysis.

As specified in §330.233(b), the owner or operator of a MSWLF shall submit a GWSAP to the Commission for review and approval prior to commencement of sampling. A copy of the approved document is to be kept in the facility's operating record and is part of the Site Development Plan (SDP). For new sites, the GWSAP must be a part of the permit application. For a site that is in existence on the effective date of the rules, the GWSAP is a Class I Modification of the SDP and, as such, requires approval from the Municipal Solid Waste Permits Section. Each proposed GWSAP or proposed revision must be submitted **in quadruplicate** to the Permits Section, Municipal Solid Waste Division, for review and approval before implementation. Any change of an approved GWSAP also requires a Class I Modification.

The GWSAP must also be submitted not less than 60 days prior to the compliance date for the site (§330.230). For new sites, the GWSAP must be approved prior to the emplacement of waste. For sites in existence on the effective date of the rules, the compliance date is determined by the distance of the facility to the nearest drinking-water intake, as specified in §330.230(c). Sites that are not subject to the new rules (those that were closed prior to the effective date for their sites) should continue ground-water monitoring as specified in their SDPs and in the former rules, and do not need a GWSAP.

By virtue of the granting of a permit, the owner or operator is solely responsible for collection, analysis, and interpretation of ground-water samples. This responsibility cannot be delegated to a consultant or laboratory. Errors of omission or commission will be deemed by the Commission to be those of the owner or operator. Accordingly, it is in the best interest of an owner or operator to obtain competent, qualified, experienced consultants and laboratories, not

selected simply on the basis of low bid, to handle all aspects of ground-water sampling if it does not have such staff of its own.

Similarly, the accuracy, validity, and sufficiency of submittals of ground-water data and interpretations for a site are fully the responsibility of the owner or operator. These responsibilities cannot be delegated. The Commission will look solely to the owner or operator as the party responsible for errors, inaccuracies, or inadequacies in a submittal. Accordingly, it is crucial for an owner or operator to know the regulatory requirements and their meanings and to engage competent staff, consultants, and laboratories to handle the submittals.

The GWSAP should include or be based on at least the activities and information described in the following sections.

## **2. Well Inspection.**

Inspect the integrity of any monitoring well prior to the commencement of purging of the well. Check the casing and concrete pad for cracks or fissures and make sure that the cap is locked and that the well has not ~~ben~~ been damaged by vandalism, animals, heavy equipment, etc. Determine that the top of casing is sufficiently elevated to prevent surface runoff infiltration into the well. Note the proximity of the well to roads and waste or other potential sources of contamination. If insects are found in or on the casing, do not use organic sprays or other potential contaminants to remove them. Similarly, organic lubricants should not be used on well components such as locks.

## **3. Water-Level Measurements.**

Prior to purging a well, measure the depth to water. All measurements must be taken from the same permanent, clearly marked, easily identified reference point, or datum, at the well to be valid. This datum is typically a point on the top of the casing or the top of the protective pipe and must be identified on the Monitor Well Data Sheet for the well. The depth to water should be recorded to the nearest hundredth of a foot. The depth measurement probe should be decontaminated prior to its use in each well. Regular calibration of the depth-measuring equipment should be specified and used; it should take into account the stretch of suspended measuring tapes, wires, or cables. After measurement, the elevation of the water level with respect to mean sea level should be calculated and reported to the nearest hundredth of a foot. The water level should also be measured in a well immediately before sampling to determine where the water level is and if there is enough water for sampling.

## **4. Well Purging.**

Bailing (manually with a bailer) or pumping (with manual, electric, or air-operated pumps) is the process of purging stagnant water from a well that may not be chemically representative of formation water. Proper purging is important to secure representative ground-water samples.

No single purge method is appropriate for all wells in all situations. To assure comparability of the ground-water samples collected from the site, the same type of purging equipment should generally be used in each of the site wells. Each well should have a dedicated pump or bailer to maximize the likelihood of obtaining a clean sample and minimize cross-contamination. If this is not possible, the sampling device must be decontaminated appropriately between wells, with a final rinse with **reagent-grade water** obtained from a laboratory. If commercial distilled water is used instead, a sample of each container of the water so used should be analyzed for volatile organic compounds (VOCs) at each event where VOCs are to be analyzed because these compounds are commonly present in such water.

Bailers, if used, should have a bottom-emptying device. It allows the bailer to be emptied slowly with minimum aeration. Pumps such as a positive-pressure displacement bladder pump or another type of pump designed to prevent air from contacting the water in the well should be used to help prevent inadvertent contamination and unnecessary aeration. Generally, the intake of the pump should be as near the water surface as possible to ensure that no stagnant water remains in the well above the screen after purging. Care should be taken during purging to avoid introducing contaminants to the water in the well. The use of disposable gloves, changed after each well, is recommended to avoid cross-contamination; latex gloves can contribute some minor contaminants if care is not used.

Because of the ease of stirring up accumulated sediments at the bottom of the well, purging should be done in ways that will minimize turbidity. Bailers should be lowered gently, not dropped, to the bottom of the screen and then pulled slowly, not rapidly, up to the surface. Likewise, pump intakes should not be set too close to the bottom of the well. It may be necessary to wait a few hours to a few days between purging and sampling for wells that have substantial suspended sediments in order to allow most of the sediments to settle. For wells that have significant levels of suspended solids, micro-purging may be an appropriate method but requires prior TNRCC approval.

During purging, at least three casing volumes should be removed from the well. The casing volume is the amount of water in the casing itself prior to purging and does not include the volume of water in the filter pack. Alternatively and preferably, purging should continue until pH, temperature, turbidity, and conductivity have stabilized and the water is clear. For wells that recharge very slowly, purging to dryness is sufficient to remove stagnant water. The well is then allowed to recover enough to allow collection of samples (often 12 to 72 hours). Where possible, the water level should be allowed to recover to within 90% of the water level prior to purging.

Data collected prior to sampling should be recorded in a field log and should include the initial depth to water, measured well depth, height of the water column, well volume, purging discharge rate, well purging time, volume of water purged from the well, a record of pH, conductivity, temperature, and turbidity readings, information from the well inspection, and any other pertinent information.

The water removed from a well during purging should be stored in a drum or similar container until the results of the analyses of ground-water samples are received. Alternatively, the water may be commingled with contaminated water in storage facilities on site that is not to be disposed of in the landfill. If analytical results indicate the contaminants are below levels of concern determined by TNRCC staff, the water can be applied to the unsaturated soil on-site, or discharged to surface water if a permit to do so is not required. The water may be treated at a waste-water treatment facility or other authorized facility if the water quality is acceptable to the facility. If the results indicate levels of contaminants that cause the water to be classified as hazardous by the TNRCC, it must be properly transported and disposed of at a hazardous waste facility. Prior to discharge of water from a well, the owner or operator should discuss proper procedures for disposal with TNRCC staff. "Contaminated surface water and ground water may not be placed in or on the MSWLF unit" (§330.56(o)(2)).

## **5. Timing and Order of Sampling.**

The elapsed time for sample collection should be as short as possible to avoid temporal variations in water levels and water chemistry. Sampling should be done preferably within 24 hours of purging. If a well is very slow to recharge, it should be sampled as soon as practicable; a maximum of seven days may be acceptable with prior TNRCC approval. Obviously, this will depend on site-specific and well-specific variations.

If contamination is known to be present in one or more wells at a MSWLF, sampling should begin at the well that is known to be least contaminated and end with the most contaminated well. Where no contamination is known, the order should generally be from the well with the highest water-level elevation to the one with the lowest elevation (upgradient to downgradient) for each group of wells completed in a water-bearing unit.

## **6. Sample Collection, Preservation, and Shipment.**

Sample collection, preservation and shipment to the laboratory are probably the most important steps in the sampling process. Physical or chemical changes occur in ground-water samples no matter how carefully sampling is done and can certainly occur if inappropriate sampling devices, collection procedures, preservatives and temperature controls, or inadequate shipment is employed.

**6.1. Sample Collection.** The need to minimize turbulence and aeration of the sample can never be overemphasized. A pump used for sampling should significantly minimize sample agitation if discharged at a very low rate. If a bailer is used, a bottom-emptying device allows the bailer to be emptied slowly from the bottom, reducing aeration and turbulence. Transfer containers are not recommended for sample collection because of the likelihood of cross-contamination. In-line, flow-through collection devices may be used to eliminate the need for transfer containers. If non-dedicated sampling devices are used, they should be clean and decontaminated using appropriate procedures before sampling each well. Do not reuse soiled sample bottles, bailer rope, rubber hose, plastic gloves, or filtration media. Keep clean

equipment off the ground to prevent contamination once the equipment is cleaned. It is useful to spread disposable plastic sheeting around a well before beginning purging and sampling. The sheeting should not be reused at other wells. Water removed during sampling and not saved must be handled in the same way as for purged water.

Generally, the first portion of water taken from a well during sampling, perhaps two liters, should be discarded to help eliminate any oxidized water that may be present at the top of the water column.

All water samples should be collected as close to the well head as practical. Do not allow the sampling device to touch the sampling container, but hold the two as close as possible to reduce aeration.

The area around the sampling point should be checked for possible sources of air contamination, particularly when sampling for VOCs.

**6.2. Field Measurements.** Slowly pour an unfiltered portion into a clean container for field measurement of temperature, specific conductance, and pH. Measure the temperature immediately. Next, measure the specific conductance of the sample to avoid any effect on the sample from salts from the pH probe, then measure the pH. Record the color, odor, foaming, presence of more than one phase of liquid, and turbidity of the sample. The equipment used for field measurements should be calibrated at least daily during sampling and provisions made for backup equipment to be available in the event of primary equipment failure.

**6.3. Sample Containers.** The volume of samples and types of sample containers depends on the parameters to be analyzed and should generally be consistent with the recommendations in Attachment A, which are based on EPA guidance. To avoid confusion, the number of containers collected from each well should be minimized.

Fill the sample containers in the following order according to volatilization sensitivity:

**VOCs** (volatile organic compounds)

**SVOCs** (semivolatile organic compounds)

**NPOC** (non-purgeable organic carbon, sometimes called TOC  
or total organic carbon)

**Metals**

**Other Inorganic Parameters**

If bailers are used for sampling, fill both VOC vials from a single bailer to prevent inhomogeneity in the samples resulting from the presence of suspended sediments. Similarly, fill NPOC replicates from a single bailer for the same reason.

All sample containers must be labeled for identification purposes. The labels should include information such as sample number, well number, site identification, analysis to be performed,

preservatives used, date and time of sample collection, and name of sampler. Information should be written with indelible ink and covered with transparent tape to protect the written data.

#### **6.4. Types of Sample Containers.**

For VOCs, use two 40-ml glass vials with special caps with Teflon® septa. The septum is correctly placed with the Teflon side toward the sample (shiny side away from the sample). Allow the water stream to flow down the inner wall of the vial to minimize formation of air bubbles. Overflow the containers slightly so that the vial has a positive meniscus. Screw the caps on carefully to avoid leaving any airspace in the vials. If an air bubble forms in the bottle, do not open the bottle to remove it but collect an additional separate sample.

For SVOCs, use one-quart or one-liter glass containers. Fill the container and cap it with a Teflon-lined lid. The septum is correctly placed with the Teflon side toward the sample (shiny side away from the sample). One quart of water is sufficient for this analysis.

For NPOC (TOC), use 100-ml amber glass containers with Teflon-lined caps, if possible. Separate samples should be collected as required, generally in triplicate or quadruplicate. No airspace should exist in the sample containers to minimize the possibility of volatilization of organics, if present. It is not necessary to add a preservative if the samples are to be analyzed within 48 hours of collection. If they are not, hydrochloric acid should be added to lower the pH to <2.

For metals, use polyethylene or glass containers. Add 5 ml of concentrated nitric acid per quart or liter of sample as a preservative. If dissolved metals are to be determined, **filter the sample before adding the preservative.**

For other inorganic parameters, use polyethylene or glass containers as recommended in Attachment A. Preservatives are not generally used except for samples to be analyzed for ammonia. If a few specific parameters are of interest and they are known to rapidly degrade chemically or biochemically, the sample may be treated with preservatives according to EPA guidelines.

**6.5 Sample Preservation and Holding Times.** Holding times and sample volumes required for each analysis should be reviewed with the laboratory prior to sampling. Suggested holding times are shown on Attachment A. Sample preservation is intended to 1) retard biological action, 2) retard hydrolysis, and 3) reduce sorption effects. Preservation methods are generally limited to pH control, chemical addition, refrigeration, and protection from light. Specific preservation methods are presented in Attachment A. For a further discussion of these methods refer to EPA SW-846, "Test Methods for Evaluating Solid Waste", 3rd edition.

**6.6. Sample Storage and Transport.** All samples should be kept cold, ideally at 4°C, and transported to the laboratory as soon as possible, preferably within 2 days of sampling.



Samples should be placed in re-sealable bags, then in an ice chest or other insulated container packed with sufficient ice or refreezeable materials to keep them as near 4°C as possible. **Don't use dry ice to chill the samples because the samples will freeze and the containers will break.**

If the samples are shipped, they and the insulated container can first be chilled with ice; after pouring off the ice and water, they can be kept cold with frozen packages of refreezeable materials such as "blue ice." The insulated container needs to be packed inside with foam, newspaper, or an absorbent material such as vermiculite to prevent or minimize the likelihood of container breakage, then thoroughly sealed with cloth tape or reinforced shipping tape. Inexpensive expanded-foam ice chests are not suitable for shipping. Under no circumstances, should water ice or dry ice be used for samples shipped via public transportation.

**6.7. Chain-of-Custody Documentation.** A suitable chain-of-custody (COC) document must accompany the samples at every step from field to laboratory and must be signed by each party handling the samples, from sampler through transporter to the laboratory, to document the possession of the samples at all times. Proper COC procedures are essential to ensure sample integrity and to provide legally and technically defensible data.

The person collecting the sample starts the COC procedure. Individuals relinquishing and receiving the samples sign, date, and note the time of transfer on the COC form. Packages sent by mail should be certified with return receipt requested to document shipment. For packages sent by common carrier, a copy of the bill of lading will suffice. Copies of the return receipt or bill of lading should be attached to the COC document. The COC document must accompany the sample during transport and shipping, and should be protected from moisture using sealable plastic bags.

**6.8. Documentation of Sampling.** Information related to a sampling event should be recorded in a bound, permanent field log book. All entries should be legible and made in black, indelible ink. Entry errors should be crossed out with a single line, dated, and initialed by the person making the corrections. An essential practice is to record sufficient information so that the sampling situation can be reconstructed without relying on the sampler's memory. Location, date, time, weather conditions, name and identity of sampling personnel, all field measurements including numerical values and units, comments about the integrity of the well, etc., should be recorded. Because this book may be the only acceptable records for legal purposes, it should be protected and kept in a safe place.

## **7. Sample Filtration.**

Samples are filtered to remove sediments that can cause interferences during analysis. Filtration also helps maintain consistency of historic databases for some parameters such as manganese and iron, which were filtered in the past. Filtering is essential in determining the concentration of **dissolved** constituents in ground water because suspended sediments in the sample can react and change the concentration of some of the dissolved constituents.

Can or should samples be filtered in the field? This issue has created much controversy among ground-water professionals and regulatory agencies. Until changes in the rules are promulgated by EPA and the TNRCC, the existing rules must be used.

As stated in §330.233(c), samples that are to be analyzed for §330.241, Table 1, parameters ("Table 1") shall not be field-filtered. Laboratory filtering of samples for metals analysis is permitted if necessary to protect analytical equipment. Because of chemical or physical changes that may occur during shipping or transport, the interpretation of "total" metals is questionable if the samples are filtered in the laboratory. It is the Commission's opinion that dissolved metals are better indicators than "total" metals, and owners and operators are encouraged to analyze samples for both "total" and dissolved metals, especially for sites that have large amounts of suspended sediments in the samples. If dissolved metals are to be analyzed, the samples should be properly filtered in the field. If field-filtering is not practical, the samples should be filtered in the lab as soon as possible. Samples to be analyzed for inorganic parameters other than metals may also be filtered for the sake of consistency (unless adsorbed or colloidal material is of interest). A note indicating whether or not the samples were filtered and the place where they were filtered must accompany the results of the ground-water analyses. The new sampling forms have a place to note if analyses are for total (T) or dissolved (D) constituents.

When samples are filtered, **add any acid preservatives after filtration to avoid breaking down clay molecules or placing adsorbed ions into solution**, which could result in the generation of artificially high concentrations of metals.

Neither field nor lab filtering is permitted for samples that are to be analyzed for VOCs, SVOCs, or NPOC. Many organic compounds are attached to solid particles, and filtering would remove them, yielding false negative results.

It is often difficult to avoid sample contamination in the field without suitable equipment. In-line filtering is very useful in reducing the contact of the sample with the atmosphere and consequently decreasing the possibilities of chemical changes in the sample. Disposable filtering equipment is preferable. Reusable filtering equipment **must** be properly decontaminated between each sample filtered.

## **8. Analytical Parameters.**

Detection monitoring is required at all ground-water monitoring wells at a site, as specified in §330.234. It must generally include monitoring for at least the constituents in §330.241, Table 1 (Attachment B), or an **alternative list**. The alternative list will comprise the constituents determined by the Executive Director as adequate for monitoring potential contamination from the MSWLF, according to §330.234(a)(1-2). The Executive Director may with reasonable cause delete constituents from Table 1, substitute inorganic indicators in lieu of some or all of the heavy metals, and/or add inorganic or organic constituents to those to be tested if they are reasonably expected to be in or derived from the waste or if they are likely to provide a useful

indication of releases from the MSWLF to the ground water. Any alternative list will be expected to include the 47 volatiles in Table 1.

Inorganic parameters other than heavy metals are useful indicators of contamination because of their abundance in waste, mobility, and lack of reactivity in ground water. Historically, many states, including Texas and Wisconsin, have relied on some inorganic constituents to indicate ground-water contamination from municipal solid waste landfills. The Wisconsin Department of Natural Resources found that five inorganic parameters (chemical oxygen demand, specific conductance, chloride, alkalinity, and hardness) were useful in predicting most VOC contamination but recommended that care should be taken in relying on them to detect all VOC contamination. Other studies have indicated that specific constituents such as ammonia are good indicators of contamination.

The Commission's rules provide a basic list of constituents to be analyzed in ground water, comprising 15 metals and 47 VOCs (§330.241, Table 1). In unaffected or pristine ground water, one would expect to find that all 62 of these constituents would be below a reasonable detection limit. Analyses for such constituents provide no information about the general ground-water chemistry, essential to determining seasonal and locational variability and in confirming that monitoring wells are completed in the same water-bearing zone (which would be expected to have similar quality throughout the site). Accordingly, the Commission recommends that the owner or operator propose substitution of several inorganic parameters for some of the 15 heavy metals (beryllium, antimony, thallium, vanadium, etc.) that are not likely to be present in ground water from a MSWLF. These substitutions should be based on specific knowledge of the site hydrogeology and the characteristics of the waste and leachate. Constituents to be analyzed, in order to successfully characterize the ground-water chemistry at each well, would typically include:

- calcium
- magnesium
- sodium
- potassium
- chloride
- sulfate
- ammonia (preferred) or nitrate
- iron (dissolved)
- manganese (dissolved)
- hardness (omit if calcium and magnesium are analyzed)
- alkalinity
- total dissolved solids (TDS)
- specific conductance (field and lab)
- pH (field and lab)

If only the Table 1 constituents are analyzed at a site and a statistically significant change (SSC) occurs in one of them, it may then become very important to determine if changes have also

taken place in the general chemistry of the ground water. The SSC may be related to locational, temporal, or seasonal effects rather than to leakage from a site.

Mercury is not included in the metals listed in Table 1. For sites that have routinely analyzed for mercury and that have found it above detection limits, it should be added to the list of detection parameters.

A site may also propose the occasional analysis of general parameters that are not be included as detection monitoring parameters. Such parameters do not require statistical analysis.

After completion of analyses of background samples for a well or a site for the detection monitoring parameters (Table 1 or the alternative list), an abbreviated list of VOCs and omission of some heavy metals may be proposed. Any deletions must be based on documentation that shows "that the removed constituents are not reasonably expected to be in or derived from the waste..." (§330.234(a)(1)). Any abbreviated list will become the new "alternative list" for detection monitoring.

## **9. Analytical Methods.**

The ground-water monitoring program must include analytical methods that are appropriate and that accurately measure hazardous constituents and other monitoring parameters in ground-water samples. Among the acceptable analytical methods are those in *Standard Methods for the Examination of Water and Wastewater*, 18th edition, 1992, or those listed in SW-846.

Most of the heavy metals in Table 1 can be analyzed by inductively coupled plasma emission spectroscopy (ICP). Antimony, beryllium, cadmium, lead, and thallium, and possibly arsenic and selenium, may require the use of a graphite furnace to achieve reporting limits that are at or below the MCLs of the metals. If a lab cannot achieve these MCLs due to matrix interference, it should filter or perform other appropriate procedures to eliminate or reduce the interferences. Dilution of a sample or other steps taken because of matrix interferences must be reported.

VOC samples should be extracted by purge-and-trap using EPA method 5030 and analyzed by EPA solid waste method 8240, 8260, or a combination of these methods. EPA recommends method 8260, which uses a capillary column to allow better separation and improved detection limits of the analyzed compounds. Bromochloromethane is used as the internal standard in Method 8240; this is one of the 47 VOCs in Table 1 and will be impossible to quantify if present in the sample. If Method 8240 is chosen, a different internal standard should be selected. We recommend that a single method be used to analyze all 47 VOCs for time-saving and economic reasons. Both of these methods (8240 and 8260) are described in SW-846.

Any additional inorganic parameters chosen for detection monitoring can be analyzed by the methods described in either of the two references above.

For those parameters that have an established MCL for public drinking-water supply systems, the laboratory should demonstrate that the method, instrument, and procedure used are capable of attaining a practical quantitation limit (PQL) **at or below the MCL** for each analyzed parameter. A document with the latest revised drinking-water standards established by the Water Utility Division of TNRCC is attached to these guidelines. A list of recommended reporting limits for the VOCs of Table 1 is given in Attachment C, as established by the Texas Department of Health (TDH) Laboratory, an EPA-certified laboratory. If PQLs higher than those in Attachment C are reported, any quantifiable amount below the PQL should be flagged to show that the compound is present but below the PQL. Documentation on the two lowest calibration points and the method detection limit (MDL) for the flagged compounds should accompany the results in such situations. The Commission may require confirmation of the flagged parameters at a later date.

The **PQL** is defined as the lowest levels of a substance that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. PQLs are likely to change during the time the GWSAP is in place in response to improvements in analytical technology. The **MDL** is the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero; it is determined from analysis of a sample in a given matrix type containing the analyte.

Vinyl chloride is a highly volatile compound that is difficult to analyze, and the Commission may accept a PQL of 5 µg/l for this compound if the laboratory cannot attain a PQL of 2 µg/l (MCL) with the existing equipment. Two organic compounds, 1,2-dibromo-3-chloropropane (DBCP) and 1,2-dibromoethane (EDB), have extremely low MCLs, 0.2 and 0.05 µg/l, respectively. It is almost impossible to report PQLs at these low concentrations without an extraction procedure preceding the injection. For these two compounds, PQLs similar to those in Appendix C are acceptable; if the PQLs are higher, the requirements for flagging described above for such a situation should be met. The Commission may require confirmation if any quantifiable amount below a higher PQL is flagged for these two compounds.

Most of the assessment monitoring parameters in Appendix II of 40 CFR Part 258 can be determined by EPA Methods 8260, 8270, and the methods specified in SW-846 for heavy metals. Other specific methods must be used to determine parameters such as cyanide, sulfide, and particularly pesticides, herbicides, phenols, nitrosamines, etc., where 8270 is not applicable or where the PQLs attainable with this method are not appropriate.

## **10. Background Samples.**

Background refers to the chemical characteristics of ground water comprising a data set to which the chemical characteristics of the current samples are compared to determine if the current samples show SSCs in those characteristics. The word "background" should not be used to describe "upgradient" water quality.

Background water quality for new and existing MSWLFs is to be established for the 15 metals and the 47 VOCs listed in Table 1 or an alternative list of detection monitoring parameters approved by the Executive Director. At least four background samples must be taken from each well, but a sufficient number of samples must be collected to generate the information required by the statistical method chosen. Dr. Robert D. Gibbons, a biostatistician with the University of Illinois at Chicago, recommends a minimum of 8 background samples from each monitoring well if the statistical approach involves intrawell comparisons and 4 background samples from each well if interwell comparison is used with 2 upgradient wells. Dr. Gibbons also suggests that one upgradient well is not sufficient to establish upgradient water quality because of natural chemical variability, both in space and in time. The TNRCC may accept the use of previously collected data for background if the samples were taken and analyzed following adequate sampling and analysis practices and if the assumptions for the statistical method are valid for the specific situation.

The length of time required to take background samples should be adequate to assure that the samples are statistically independent. For most sites generally not more than six months, but longer times may be necessary between sampling events to allow hydraulic and chemical stabilization of the formation to occur. Seasonality, site conditions, and choice of statistical methods should also be considered. The spacing of background samples is described in section 14.1. Background samples taken during both low and high rainfall periods would be useful to determine the effects of rainfall on ground-water chemistry.

Background samples are to be taken from each existing well that is part of the ground-water monitoring system, as well as from any new, repaired, or replaced monitor well that belongs to the system. After the background analyses have been completed, the data will be treated statistically and background concentrations established for each parameter. Although these analyses are used to obtain background data for statistical analysis, they will be subject to review for indications of ground-water contamination by the Commission based on historical data and other information about the site. The Commission may require statistical analyses, using ANOVA or other appropriate methods, during background sampling to help determine if contamination may be present.

## **11. Detection Monitoring.**

After the completion of background sampling, all the monitoring wells are to be sampled on a semi-annual basis (starting six months after completion of background) unless another sampling schedule is proposed and approved by the Executive Director. In no case will the samples be taken less than annually. The logic for selecting an alternative frequency must be substantiated. For example, in some areas where ground-water flow velocities are low, an annual frequency may be sufficient; this same frequency could allow contaminants to travel considerable distances before detection in an area with higher flow velocities. The selected frequency of sampling normally continues for the life of the site and the post-closure period, but it can be altered if SSCs occur, if site conditions change, or if the Executive Director deems it necessary.

The monitoring parameters are discussed in Section 8.

Most concerns are with statistically significant increases in the concentrations of parameters. A statistically significant decrease from background for a parameter such as pH can also indicate contamination, and a decline in a naturally occurring high chloride concentration in downgradient wells may indicate recharge or dilution by fresher water infiltrating from the landfill.

Most of the suggested indicator parameters have spatial variability, and many of them can be changed by human activities or by natural geologic variations. Climatic variations (short duration, seasonal, and/or long-term) can also affect the concentrations of indicator parameters.

The goal of detection monitoring is finding specific constituents that may be leaking from the site, so it is very useful to regularly analyze leachate pumped from the site. Leachate should be analyzed for the detection monitoring parameters. Leachate analysis data may be helpful in supporting a reduction of the number of parameters monitored from the monitoring wells and may be crucial in showing that a SSC was probably not from the MSWLF.

## **12. Assessment Monitoring.**

The occurrence of a SSC from background for a detection monitoring constituent at a sampling event will generally result in the implementation of assessment monitoring. Unless the owner or operator can show to the satisfaction of the Executive Director that the SSC resulted from an error, seasonal variation, or cause other than the MSWLF, the owner or operator must initiate an assessment monitoring program no more than 90 days from the report of the SSC to the Commission. The Executive Director may make a determination that selective re-sampling, possibly with filtration of metals, is to be accomplished prior to the initiation of more rigorous assessment monitoring. The owner or operator may voluntarily initiate re-sampling without waiting to make the notification of the SSC.

Assessment monitoring will be done on a site-specific basis in accordance with §330.235 and will require the concurrence of the Executive Director.

## **13. Quality Assurance and Quality Control (QA/QC).**

Assessment of data reliability is essential to determine if the analytical parameters detected are truly present in the ground water at the reported concentrations and to confirm that all the compounds of interest in the sample have been detected. Any laboratory that analyzes parameters in Table 1 or an alternative list is expected to follow appropriate QA/QC practices. A good QA/QC program ensures that the data generated are accurate and precise and are legally defensible. It enhances consistency in data analysis.

Quality-assurance (QA) procedures address both field and laboratory activities. Quality-control (QC) procedures must be specified for estimating the precision and bias of the data. Certain minimum requirements for QC samples have been established by EPA and must be met in order

to satisfy minimum criteria for acceptable data quality. A laboratory should use QC procedures that are equivalent to those provided for each method as described in the latest edition of SW-846.

The project documentation should cover the type of operations to be performed, including at least the following areas and activities. The location where decontamination of sampling equipment will occur should be described, and the method, solvents, and purity of water used for this purpose specified, as well as the method for storage and disposal of waste material generated during sampling. Sample management procedures should specify containers, volume of samples, preservatives, labeling, holding times, chain of custody, and shipment methods. Procedures describing how the sampling operations are to be performed and the methods to be used in the field to determine a chemical or physical parameter should be specified. Calibration and maintenance procedures, with lists of the field equipment and instrumentation, and a description of methods to ensure that the equipment is in working order (and corrective measures if it is not) should be specified. Sample collection records should contain the names of personnel conducting the activity, sample numbers, location, date, equipment used, climatic conditions, and any other useful observations. Documentation for all QC samples such as trip and equipment blanks, and duplicate samples must be recorded.

The laboratory that performs the analyses should provide its own Laboratory Standard Operating Procedures (LSOP) as part of the QA requirements. The LSOP should describe a detailed program of how the laboratory will proceed to provide data of stated quality with a stated probability of being correct including all procedures to handle and analyze the samples from receipt until the results are reported. An LSOP should also address determination of detection limits and proper reporting of results. MDLs for all the parameters of Table 1 can be determined by Appendix B to CFR part 136 of October 26, 1984, vol. 49 no. 209.

A permittee may submit a GWSAP indicating the minimum QA/QC requirements expected from the laboratory performing the analyses. At a later date, once the laboratory is chosen and prior to the first sampling event, the specific LSOP is to be submitted for review by the TNRCC Ground-Water Monitoring Team. If the owner or operator changes laboratories, the new laboratory must meet the minimum QC/QA requirements in the approved GWSAP and a LSOP for the new laboratory must be submitted for the Team's review and acceptance. Neither of these submittals would be a Class I Modification to the SDP.

The laboratory QA/QC procedures reduce random and systematic errors and maintain them within tolerable limits. Procedures shall be in place for demonstrating proficiency with each analytical method routinely used in the laboratory including documentation of precision, bias, methods and frequency of the determinations of MDLs, checks on reagent purity and glassware purity, and spike and surrogate recoveries. The laboratory should also have methods for establishing control limits for analysis, documentation on the effect of the matrix on the analysis, and procedures followed for reviewing, approving, and revising laboratory records. Equipment maintenance and calibration records documenting the frequency of maintenance, standards used, calibration history, and verification of the accuracy of all working standards against appropriate



primary grade standards shall be kept. All sample management records shall be maintained and updated regularly. Records of samples received, steps of sample handling, assigned responsibilities, chain of custody, and reagents used and their date of purchase are other important aspects that should be addressed in a LSOP. Finally, the raw data and calculated results for all QC and field samples and standards shall be maintained in appropriate permanent records in the laboratory.

Some field and laboratory QC procedures are described below.

**13.1. Trip Blanks.** A trip blank is a laboratory-grade distilled water sample poured into a clean sample container that is transported to and from the site in the same manner as the sample containers. The purpose of the trip blank is to determine if any of the sample bottles or collected samples have been contaminated before or during sampling or if sample shipment, handling, and storage have had an impact on the sample integrity. VOCs detected in these blanks, for example, could indicate poor laboratory cleaning procedures or contaminated distilled water.

**13.2. Field Blanks.** A field blank is prepared in the field by pouring laboratory-grade distilled water brought from the laboratory into sample containers opened in the field, then returned with the samples to the laboratory for analysis. It is used to check sampling procedures and airborne contaminants. VOCs detected in a field blank could, for example, indicate contamination from an open can of gasoline, an exhaust from a car or truck, or airborne contamination from a special trench where petroleum products are disposed of.

**13.3. Equipment Blanks.** An equipment blank is a sample of laboratory-grade distilled water processed through the sampling equipment in the same manner as the actual ground-water sample to determine the effectiveness of equipment cleaning procedures. For example, VOCs detected in equipment blanks could indicate inadequate bailer or pump rinsing, or even contaminated distilled water.

The results from these blanks will allow determination of whether the constituents reported by the laboratory are true constituents of the ground water or arise from some other source. Typical collecting frequencies are one trip blank for each sampling event, one field blank per day or one every 10 wells, whichever is greater, and one equipment blank per day or sampling event. It is appropriate to collect the field blanks when sampling downgradient wells. If a well is contaminated, a field blank collected close to the contaminated well, in addition to the regular blank, may help determine the possibility of surface migration of landfill gas.

**13.4. Field Duplicates.** Field duplicates are two samples taken from the same well, preferably the same bailer if bailers are used, but labeled differently so that the laboratory is unaware that the samples are duplicates. Analysis of duplicate samples provides a check on the precision of the laboratory techniques. It is good practice to take one field duplicate every 10 wells, or one per sampling event for fewer than 10 wells.

**13.5. Split-Samples.** In many instances **split-samples** are taken to verify the analytical procedures and the quality of data generated by a laboratory by comparing results from another independent laboratory. To secure a true split, water that is going to be analyzed for the same parameters must come out of the same bailer if bailers are used and divided as evenly as possible between the sample containers. Sample pre-treatment and handling methods and, if possible, methods of analysis should be the same for both sets of samples.

**13.6. Other Procedures.** Reagent blanks, method blanks and spike blanks, spike samples, duplicate spike blanks, and duplicate spike samples are **other procedures** that a reputable laboratory will follow as part of its QC procedures. Reagent blanks are samples of pure reagents that are introduced in the GC/MS equipment to determine the presence of impurities that could contribute to incorrect positive determinations. Method blanks are samples of all the reagents used in the determination, added in the same volumes or proportions as used in the sample processing, that are run through the same procedures and analyzed exactly as the samples. Analysis of method blanks will indicate if impurities are contributing to incorrect positive determinations and/or if the methods of preparation and analysis are operating properly. Spike blanks will furnish information on the effect of the preparation and analysis procedures on the recovery. Spike samples are important to calculate accuracy or percent recovery of a particular parameter and will provide information on the effect of the matrix on recovery. Spike duplicate blanks and spike duplicate samples are very significant because they allow the laboratory to check precision and accuracy at the same time.

A QC program should also incorporate documentation of the procedures used to verify data that fail internal checks and of the internal and external standards used to test instrumentation, methodologies, and personnel. Each analyst should go through a proficiency test, and this should be documented.

Proper calibration procedures are crucial to correct determination of concentrations of analytes. Appropriate calibration curves (method/analyte) should be checked at least daily (or at the beginning of the run if analyses are less than daily) for graphite furnace and ICP analyses; one point should then be run to be sure the instrument is calibrated. An external standard from a source different from the one used for the calibration curve should also be checked. For ICP analyses, a calibration blank should be run to determine that the instrument zeroes properly; this should also be done for a graphite furnace if this is not done automatically. For ICP analyses, interference checks should be made at the beginning and end of a run to be sure that any interference is properly accounted for. For both methods, an instrument check standard and calibration blank should be run at the beginning and end of the run and every 10 samples. Duplicates and spikes should be checked at every 10 samples.

For organic compounds, daily calibration checks must meet specified, suitable QC requirements. If they do not, equipment should be recalibrated or other appropriate steps should be taken. Recalibrate as frequently as necessary, at least every two weeks. Run point calibration checks as recommended for the specific method. Single-point calibration checks can be prepared from a source different from the one used for the calibration curve.

## 14. Statistical Methods.

Statistical treatment of the analytical results is required under the rules in §330.233(f) and (g). The purpose of the statistical evaluation of the data is to determine if "there is evidence of a statistically significant change [SSC] from background values for each [detection-monitoring] constituent required in the ground-water monitoring program." The intent of using SSC rather than statistically significant increase was to allow for the detection of adverse changes in pH; generally speaking, only increases of the values of constituents other than pH will be considered adverse, although exceptions may occur.

The rules provide for the use of a wide variety of statistical methods but require that the method chosen for a constituent be appropriate for the constituent, for the data available, and for the site. It is crucial to select appropriate methods for a variety of reasons: the need to be able to detect a release in a timely way, the desire to evaluate the data quickly and clearly, and the intent to detect SSCs that may indicate contamination. "Appropriate" methods cannot be chosen in advance of sampling, since the "appropriate" methods depend on the distribution of data. On the other hand, the methods likely to be used must be determined before sampling in order to properly structure the sampling schedule.

It is, in fact, difficult to determine which methods may be most appropriate for statistical analysis of specific constituents until at least a few background samples have been taken. Because of this difficulty, the TNRCC recommends that a flow chart be provided in the GWSAP showing the methods likely to be used and the decision points (and their basis) for making the selections. Simply listing all the methods that might be used at a site will not be adequate for a GWSAP.

Two documents that summarize statistical methods recommended by EPA for ground-water monitoring are:

Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance, April 1989 ("Interim Final Guidance") and

Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Draft Addendum to Interim Final Guidance, July 1992 ("Addendum").

Both are published by the Office of Solid Waste, U.S. Environmental Protection Agency. The Addendum updates and corrects some of the concepts and methods in the original publication; it is an important part of the material and should not be overlooked. Numerous other sources of information discuss various statistical methods in greater detail than the EPA documents. Some of these sources include Davis and McNichols (1987), Davis (1993), Dixon (1953), Gibbons (1991a, b, and c; 1992; and 1994), and Gibbons (et al. 1992). In addition, introductory texts on statistics will provide the underlying concepts for the statistical methods used in ground-water monitoring.

**14.1. Independent Samples.** The statistical methods generally used in ground-water monitoring require that data be statistically independent for the results to be strictly valid. This means that samples cannot be taken so close together in time that they are essentially from the "same" water, meaning that an adequate amount of time must elapse between sampling events. How much time is adequate? Section 3 of the Interim Final Guidance suggests a method for estimating the minimum interval based on site-specific data. Generally, the more permeable the water-bearing zone and the steeper the hydraulic gradient, the less time is necessary between sampling events to assure independence of samples. Two examples are given below to provide some indication of the time intervals that might be needed.

Example 1. For a site in Upper Cretaceous weathered clay and shale along and east of Interstate 35 between Austin and Dallas, the horizontal hydraulic conductivity ( $K_h$ ) would typically be  $1 \times 10^{-6}$  cm/sec, or about 0.003 ft/day. The effective porosity ( $N_e$ ) would be 0.01 to 0.001, increasing with more fracturing; we'll use 0.015. The hydraulic gradient ( $i$ ) is typically about 10 feet per 1000 feet, or 0.01. Substituting these values in the Darcy equation

$$V_h = K_h * i / N_e$$

and solving for  $V_h$ , the horizontal velocity, we have

$$\begin{aligned} V_h &= 0.003 \text{ ft/day} * 0.01 / 0.015 \\ &= 0.002 \text{ ft/day.} \end{aligned}$$

This means that, barring any other activities or changes, the water in a monitor well with 4-inch (0.333 ft) casing would change completely about every six months. In that case, samples taken no more often than that could probably be considered independent samples.

Example 2. For a site in gravelly sand along a major river such as the Trinity River,  $K_h$  would typically be 0.3 cm/sec, or about 850 ft/day.  $N_e$  would be about 0.2, and  $i$  might be about 0.006.

Solving for  $V_h$ ,

$$\begin{aligned} V_h &= 850 \text{ ft/day} * 0.006 / 0.2 \\ &= 25.5 \text{ ft/day.} \end{aligned}$$

This means that samples taken a day apart in a well are probably independent.

The Interim Final Guidance provides default values for effective porosity and typical values for hydraulic conductivity that can be used for estimating the horizontal velocity if the hydraulic gradient is known, but only if site-specific data are not available.

Unfortunately, independence in space is also important to assure that samples are statistical independent. Such spatial independence is much more difficult to determine than independence in time; accordingly, it is usually omitted in most discussions of the applicability of statistical methods to ground-water monitoring.

**14.2. Graphical Methods.** Most owner, operators, consultants, and regulators find it easier to understand a graphical plot of data than a statistical summary. We recommend that simple graphs plotting constituent values with time be prepared for each constituent of interest (usually only those that have values above detection limits). Such graphs provide visual indication of increasing or decreasing trends, and sometimes of seasonality or other natural variation. Most spreadsheet and statistical software will provide such graphs in a variety of formats.

Another popular graphical method is the boxplot, or box-and-whisker plot. These are described in Section 1.2.1 of the Addendum, as well as in some statistics books. Boxplots provide a very useful way to compare all the data for a well to those for other wells, or all upgradient well data to all or individual downgradient well data. Boxplots graphically show the range of the data, the median, upper and lower quartile values. At least five data points are necessary to make boxplots.

Other straightforward graphical methods are useful for a variety of purposes. For example, Stiff and Piper diagrams are helpful in determining whether or not water from different wells is likely to be coming from the same water-bearing zone; these require analysis of the major inorganic ions calcium, magnesium, sodium, potassium, bicarbonate, carbonate, sulfate, chloride, and nitrate (if elevated).

**14.3. Comparisons.** At least three types of comparisons are possible at a site with more than one well. First, the current data for a well may be compared to the historical data for the same well (intrawell comparison). Second, one downgradient well may be compared to one or a group of upgradient wells (interwell comparison). Third, a variation of the second, a group of downgradient wells may be compared to a group of upgradient wells. Further, most of the methods only consider one constituent at a time, but at least one method (Poisson prediction limit) allows for the possibility of combining more than one constituent. The Poisson distribution is used to describe "rare" events such as a high percentage of non-detects. Gibbons (1987b) presents a statistical method of analysis based on the Poisson distribution.

It is important to determine which of the comparisons are likely to be useful before selecting the method(s) to be used. By useful, we mean the method that has an acceptable Type I error rate and maximizes the statistical power.

Perhaps the most serious problem associated with comparison of downgradient water quality with upgradient water quality is the underlying assumption that the two sets of data are from water that has everywhere had an identical history. This assumption would imply that the upgradient and downgradient water would have the same time of infiltration, same period of contact with

the water-bearing sediments, same chemical reactions with the materials passed through, and no other differences from one part of the water-bearing zone to another. Such a situation is impossible. It is, nonetheless, the assumption necessary to make such comparisons. For this reason, it is better to use intrawell comparisons, the comparison of current data from a well with uncontaminated historical data from the same well, because at least the spatial variations from one well to another are eliminated. It is not always possible to use intrawell methods effectively because an old landfill or other source of contaminants may be or have been in existence upgradient from the well or wells of interest at the existing or new landfill. It would therefore be difficult for intrawell methods to "see" or detect releases due to the masking effect of using contaminated background data. For sites where the hydraulic gradient is indefinite, an intrawell comparison is probably the only useful method.

One must choose wisely in order to make proper statistical analyses that do what they are supposed to do--detect contamination in a timely way--and do so without large errors. The alternatives are that contamination is not detected until too late when remedial action costs will be very high or that "contamination" is detected and assessment monitoring is implemented when no such contamination is present.

In order to assist in selection of the appropriate methods, flowcharts can be valuable tools. Flowcharts are presented in the Interim Final Guidance document and in Sara and Gibbons (1991).

**14.4. Normality of Data.** Most statistical methods are based on the assumption that the population from which the data are taken is normally distributed. These methods also apply to data from a population that has a normal distribution after being **transformed** by mathematical manipulations such as logarithms to a normal distribution. In that case, the data are treated statistically after the appropriate transformation. Most statistical treatments suggest only taking logarithms for data transformation, but other transformations such as square roots or raising data to a power greater than one can be effective.

Some ground-water data are log-normal. This means simply that the logarithms of the population data are normally distributed and that the logarithms of the data are the values used in the statistical methods. Because log-normal distributions are common, the Addendum recommends taking logarithms first when checking for normality, then if that fails, checking the original data for normality.

Several tests are available to check for normality of the data. Such tests include the Shapiro-Wilk for sample sizes up to 50 and Shapiro-Francia for sample sizes greater than 50.

If data are not normally distributed, either raw or transformed, then only statistical methods that do not require or assume normality can be used (e.g., nonparametric methods).

**14.5. Statistical Methods.** Numerous statistical methods (too many to name here) can be used for analysis of a data set, but the crucial issue is whether or not the "appropriate"

method is used in the analysis. All statistical methods have certain assumptions that must be valid in order to correctly apply the method. When a statistical method is chosen, it may be crucial that the assumptions of the method accurately depict the true situation (reality).

**14.5.1. Analysis of Variance (ANOVA).** This method is one of the better-known methods, widely used in a variety of disciplines and with considerable history of development. Because of the natural variability that exists in any ground-water system and the way that ANOVA pools the variance, the method is not useful for all analyses of ground-water monitoring data. Other methods are also available for analyzing ground-water data, such as tolerance intervals and prediction limits. Parametric and nonparametric ANOVA methods are discussed below, as presented in the Interim Final Guidance and Addendum.

If (1) original or transformed data are normally distributed, (2) group variances are approximately equal, (3) non-detects don't exceed 15%, and (4) at least four data points are available for each well being used, then **parametric ANOVA** is an available method. Section 5.2 of the Interim Final Guidance has a discussion of the method and its uses. As noted in the paragraph above, natural variability in ground-water systems makes ANOVA procedures not particularly useful.

If non-detects exceed 15% or data are not normally distributed or group variances are not approximately equal, then **non-parametric ANOVA** can be used. The Wilcoxon Rank-Sum, also known as the two-sample Mann-Whitney U Test, is a useful method. The Kruskal-Wallis can also be used but not for comparison of two groups, such as a downgradient well with grouped upgradient well data. Four samples each for the downgradient well and the upgradient well group are a minimum for the Wilcoxon Rank-Sum method. For the Kruskal-Wallis method, the Addendum suggests the use of at least three well groups with at least four observations per group.

**14.5.2. Statistical Intervals.** Tolerance intervals, prediction limits, and confidence intervals are types of statistical intervals that can be constructed from sample data. Each type has specific uses and limitations. A good discussion of these methods is in Hahn and Meeker (1991).

Tolerance intervals are suitable for large monitoring networks and prediction limits for small networks. Gibbons (1991b) describes when and why tolerance intervals should be used in ground-water data analysis and how tolerance intervals relate to prediction limits. Procedures for combining prediction limits with verification resampling, in order to achieve acceptable error rates, are described by Gibbons (1990a and 1991c). These combined procedures require verification resampling for samples that initially exceed the prediction limit.

**Prediction limits** can be used both for comparison of downgradient wells to upgradient wells (interwell comparison) and for comparison of current well data to previous data for the same well (intrawell comparison). Prediction limits provide an estimate of an interval that will include values of future measurements based on previous measurements, with a given level of

confidence. The previous measurements may be background data for either a group of wells (interwell comparison) or a single well (intra-well comparison). If an intra-well comparison is being done, the data used for constructing the prediction limit (i.e., background data) must be shown to have no evidence of contamination from the site.

If the original or transformed data are not normally distributed, then a non-parametric prediction limit can be calculated, as described by Gibbons (1991a and 1991c). Normal tolerance intervals and prediction limits are described by Gibbons (1987a). EPA guidance suggests that the non-parametric method, however, requires at least 20 samples.

**Tolerance intervals** can be used for comparison of downgradient data to upgradient data. Tolerance intervals are interval estimates based on previous measurements that will contain a given percent of background measurements with a given percent confidence. A tolerance interval is constructed from upgradient well data. Downgradient well data, presumed to be from the same data distribution set as that of the upgradient wells, are compared to the upper tolerance limit. If any downgradient value exceeds the limit, then significant evidence of contamination is deemed to be present.

If the original or transformed data are not normally distributed, then a non-parametric tolerance interval can be calculated. Unfortunately, EPA guidance suggests that at least 19 samples are necessary to ensure a 95% level of confidence.

**Control charts** resemble the prediction interval method by determining from historical data an upper expected limit for the values of uncontaminated samples. Because the limit is calculated on historical data, the method is only appropriate for initially uncontaminated wells; data so used must be shown not to be contaminated by landfill activities. An advantage to control charts is that the data are graphically plotted with time, making it easier to understand what's happening and easier to see trends prior to determination of contamination. A disadvantage to control charts is that they are useful only for constituents that do not have a large percentage of non-detects. At some sites, only a few inorganic parameters will thus be suitable for preparation of control charts. A minor disadvantage to control charts is their sensitivity to seasonal variations; these are commonly not known or understood at most sites and the variations are generally assumed to be due to other natural causes.

**Shewhart-CUSUM control charts** are recommended in the Interim Final Guidance and also discussed in the Addendum. To use the Shewhart-CUSUM control chart for analysis, the original or transformed data must be (1) normally distributed, (2) independent, (3) generally above detection limits, and (4) uncontaminated by site activities. At least six and preferably eight historical data points are needed to determine the upper limit and provide adequate statistical power for the test. If no contamination is observed over a period of time after the original data were collected and no adverse trend is obvious, then the control chart can be updated with the additional data. The new data should be compared to the older data using a t-test; no significant difference at the 5% significance level means that the new data may be added.



**14.6. Handling of non-detects.** All the detection constituents being analyzed at a site or from a well may be below the appropriate detection limits, indicating no SSCs. The opposite of having all non-detects is having all detects, either for an individual constituent or for all the constituents. Probably more likely, some constituents, usually the uncommon VOCs and metals, will always be below detection limits and some of the more common VOCs and metals will be above detection limits at some events.

Many of the acceptable statistical methods have limits on the absolute number or percentage of non-detects that can be present in the data, and they have particular methods for handling those non-detects.

The Addendum recommends several procedures for analyzing non-detects with ANOVA and statistical intervals; they are briefly described in the following paragraphs.

A brief discussion of procedures for handling non-detects with ANOVA is presented in the Interim Final Guidance. Some of the useful statistical tests are the Wilcoxon Rank-Sum and Kruskal-Wallis tests.

When statistical interval methods are to be used to compare background data against each downgradient well separately, Cohen's method or Aitchison's method may be appropriate for handling non-detects. The Addendum discusses the selection of the proper methods by plotting the data on Censored Probability Plots and Detects-Only Probability Plots, possibly followed by calculation of Plot Correlation Coefficients.

Sara and Gibbons (1991) present methods for handling up to 90% non-detects and fewer than 10% non-detects, as follows.

If at least 10% of the ground-water samples are above the detection limit, then the mean and variance of the data distribution can be approximated (Aitchison, 1955). After approximating the mean and variance, normal tolerance intervals and prediction limits procedures can be used to analyze the data. A discussion of normal (parametric) tolerance intervals and prediction limits can be found in Gibbons (1987a).

When fewer than 10% of the ground-water samples are above the detection limit, Gibbons (1987b) suggests a statistical approach for analyzing the data, using tolerance intervals and prediction limits for the Poisson distribution. The limits can be applied to data expressed as number of compounds detected per analysis or as concentrations.

**14.7. Seasonality.** Seasonal variation of ground-water chemistry is well-known in Texas, and Texas is well-known for substantial variations in climate. Fortunately, the constituents that seem to show the most variation are the major ions; this may simply be the result of inadequate data for metals and VOCs. Determination of seasonality requires adequate data, that is, data collected over a full range of seasons (generally, rainfall variability), in order

to make proper adjustments for seasonal variation of constituent values. Effects of seasonal variation are very site specific and should be carefully considered.

#### **14.8. Statistics References.**

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## **15. Reporting and Submittals**

The results of the analyses of ground-water samples collected during background and detection monitoring must be submitted to the Commission not later than 45 days after each sampling event. Triplicate copies of the results are to be submitted on the attached TNRCC-0312 form with all the appropriate heading information completed. The form may be reproduced with the items in the same order but with modifications to allow ease of typing or computer printing. In no case should the forms be larger than 8½ by 11 inches. Submittals are accepted either as hard paper copies or, with prior approval, on computer diskettes. A text discussion of the monitoring results will be helpful in the interpretation of the data and can be attached to the TNRCC report form.

The first page of TNRCC-0312 must be completely filled out, and signed and dated by the site operator. If a signed laboratory report does not accompany the analyses, the first page must also be signed and dated by the laboratory manager.

The second and third pages of TNRCC-0312 list the 15 metals and 47 VOCs of Table 1, §330.241. The 47 VOCs are listed by their Chemical Abstracts Service (CAS) registry number. The analytical methods used for each of the 62 constituents that are to be analyzed must be listed. The PQL must also be given for each of the analyzed constituents. It is not satisfactory to submit only a laboratory report of the data without completing pages 2 and 3 of TNRCC-0312.

The fourth page of TNRCC-0312 is for listing the inorganic constituents and other parameters, which may also be part of the sampling requirements for a specific site. As on pages 2 and 3, the analytical methods and PQLs must be shown for each analyzed constituent or parameter. Additional sheets can be used if necessary.

The analyses should include the laboratory report itself, appropriate laboratory QA/QC data, and copies of the chain-of-custody forms, some of which may be required by the GWSAP.

As in the past, every submittal (including the cover letter) is to be in triplicate--one original and two copies. The original is filed in TNRCC Central Records in Austin, one copy is sent to the appropriate Regional office, and one copy is used as a work copy by the Commission staff. The Commission is reviewing procedures for submittal in part on diskette and will consider proposals from an owner or operator to do so.

Not later than 60 days after each sampling event, the owner or operator must notify the Executive Director in writing if there has been a SSC from background of any tested constituent at any monitoring well. Especially if there has been a SSC, the statistical data should be reported with the notification to allow TNRCC staff to review the statistical procedures used in the determination. If such a change has occurred and the owner or operator thinks that it resulted from a source other than the MSWLF unit, then the owner or operator may submit evidence to support his or her view. He may propose to re-sample all or some of the wells for all or some of the parameters, review the analytical results with the laboratory, review the statistical procedures used, and/or explain with the proper documentation the cause of the SSC. If re-sampling is proposed, it should be performed as soon as possible, since the report demonstrating the basis of the statistical change must be submitted and satisfactorily approved by the Commission not later than 90 days after the first sampling event. If the substantiation is not acceptable to the Executive Director, the owner or operator must initiate an assessment monitoring program within 90 days of the date of the notification of the SSC. The assessment monitoring program must be approved by the Executive Director before implementation.

## **16. Safety Plan.**

Common sense is a vital element of safe conduct at all solid waste facilities and during sampling and analysis. Situations encountered are such that there will not always be guidance available on-site. A site-specific safety plan should be developed and submitted with the GWSAP to indicate the procedures that will be followed and implemented during sampling and transport.

A plan outlining a summary of the work tasks, site conditions, parties involved, and assigned responsibilities should be prepared. Emergency communications and response procedures showing the types of potential and existing hazards, exposure routes, MSDS information, instrumentation and calibration required, escape routes, first aid support kits, and routes to the nearest hospital must also be considered. A general site location map and a detailed facility map with different escape routes is essential.

When sampling at the site, avoid the introduction of contaminants into the body by ingestion, absorption, and respiration. Smoking, chewing, drinking, and eating are all prohibited at a waste site. Monitor-well water should not be allowed to come in contact with the eyes, mouth, or skin. Special care is necessary when handling sample containers, some cleaning solutions, and sample preservatives. Combination of some reagents may result in a violent reaction.

Walk carefully and be aware of steep slopes, unstable ground, poison ivy, fire ant mounds, debris piles, poisonous snakes and spiders, stinging insects, ticks, and mosquitos. Wear proper garments such as boots, hats, gloves, safety glasses, and breathing apparatus to protect from snakebites, punctures, and exposure to sun, wind, insect bites, and harmful gases. Watch out for heavy equipment moving around the site.

A very important safety procedure is to have a partner who can help with sampling and transport and will be ready to render aid to the second person or go for help if it becomes necessary.

## **17. Acronyms and Abbreviations**

**ANOVA**--analysis of variance

**CAS**--Chemical Abstracts Service

**CFR**--Code of Federal Regulations

**COC**--chain of custody

**EPA**--U. S. Environmental Protection Agency

**GC/MS**--gas chromatograph mass spectrometer

**GWSAP**--ground-water sampling and analysis plan

**LSOP**--laboratory standard operating plan

**MCL**--maximum contaminant level

**MDL**--method detection limit

**MSDS**--material safety data sheet

**MSWLF**--municipal solid waste landfill facility (=site)

**NPOC**--non-purgeable organic carbon

**PQL**--practical quantitation limit

**QA**--quality assurance

**QC**--quality control

**SDP**--site development plan

**SSC**--statistically significant change

**SVOC**--semivolatile organic compound

**TAC**--Texas Administrative Code

**TNRCC**--Texas Natural Resource Conservation Commission

**TOC**--total organic carbon

**VOC**--volatile organic compound

mg/l--milligrams per liter, approx. equal to parts per million

µg/l--micrograms per liter, approx. equal to parts per billion



## **Attachment A**

### **Recommended Sampling, Preservation, and Storage Procedures for Ground-Water Monitoring**





## Attachment A

### Recommended Sampling, Preservation, and Storage Procedures for Ground-Water Monitoring

<u>Parameter</u>	<u>Recommended Containers</u>	<u>Preservation</u>	<u>Maximum Holding Time</u>	<u>Minimum Volume</u>
pH	P,G	None	Analyze immediately	25 ml
Spec. Cond.	P,G	None	Analyze immediately	100 ml
Temperature	P,G	None	Analyze immediately	
Heavy Metals (includes iron and manganese)	P,G	*Acidify w/HNO <sub>3</sub> to pH<2, 4°C	6 months except 28 days for Hg	1 liter
Calcium, Magnesium, Sodium, Potassium, Fluoride, Sulfate, Chloride, and Hardness	P,G	4°C	28 days	1 liter
TDS (may be included with above parameters)	P,G	4°C	7 days	1 liter
Nitrate	P,G	4°C	48 hrs	100 ml
Ammonia	P,G	4°C; acidify w/H <sub>2</sub> SO <sub>4</sub> to pH<2, 4°C	7 days; 28 days if acidified	500 ml
Alkalinity	P,G	4°C	48 hrs	200 ml
NPOC	G amber, T-lined caps	4°C; acidify w/HCl to pH<2, 4°C	48 hrs; 28 days if acidified	100 ml/ replicate
COD	P,G	4°C; acidify w/H <sub>2</sub> SO <sub>4</sub> to pH<2, 4°C	48 hrs; 28 days if acidified	100 ml
SVOC	G, T-lined caps	4°C	7 days until extraction, then analyze within 40 days	1 liter
BOD	P,G	4°C	24 hrs	1 liter
VOC	G, T-lined septa	4°C; acidify w/HCl to pH<2, 4°C	14 days	2 x 40 ml

P=Polyethylene, G=Glass, T=Teflon.

\*If analyzing for dissolved metals, filter in the field before acidifying.



## **Attachment B**

### **Table 1 Constituents, 30 TAC §330.241**



## Attachment B

Table 1 Constituents, 30 TAC §330.241

**Heavy Metals (Total):**

antimony  
 arsenic  
 barium  
 beryllium  
 cadmium  
 chromium  
 cobalt  
 copper  
 lead  
 nickel  
 selenium  
 silver  
 thallium  
 vanadium  
 zinc

**Organic Constituents:****CAS No.**

acetone	67-64-1
acrylonitrile	107-13-1
benzene	71-43-2
bromochloromethane	74-97-5
bromodichloromethane	75-27-4
bromoform (tribromomethane)	75-25-2
carbon disulfide	75-15-0
carbon tetrachloride	56-23-5
chlorobenzene	108-90-7
chloroethane (ethyl chloride)	75-00-3
chloroform (trichloromethane)	67-66-3
dibromochloromethane (chlorodibromomethane)	124-48-1
1,2-dibromo-3-chloropropane (DBCP)	96-12-8
1,2-dibromoethane (ethylene dibromide, EDB)	106-93-4
o-dichlorobenzene (1,2-dichlorobenzene)	95-50-1
p-dichlorobenzene (1,4-dichlorobenzene)	106-46-7
trans-1,4-dichloro-2-butene	110-57-6
1,1-dichloroethane (ethylidene chloride)	75-34-3
1,2-dichloroethane (ethylene dichloride)	107-06-2
1,1-dichloroethylene (1,1-dichloroethene)	75-35-4
cis-1,2-dichloroethylene (cis-1,2-dichloroethene)	156-59-2
trans-1,2-dichloroethylene (trans-1,2-dichloroethene)	156-60-5
1,2-dichloropropane (propylene dichloride)	78-87-5
cis-1,3-dichloropropene	10061-01-5
trans-1,3-dichloropropene	10061-02-6
ethylbenzene	100-41-4
2-hexanone (methyl butyl ketone)	591-78-6
methyl bromide (bromomethane)	74-83-9
methyl chloride (chloromethane)	74-87-3
methylene bromide (dibromomethane)	74-95-3
methylene chloride (dichloromethane)	75-09-2
methyl ethyl ketone (MEK, 2-butanone)	78-93-3
methyl iodide (iodomethane)	74-88-4
4-methyl-2-pentanone (methyl isobutyl ketone)	108-10-1
styrene	100-42-5
1,1,1,2-tetrachloroethane	630-20-6
1,1,2,2-tetrachloroethane	79-34-5
tetrachloroethylene (tetrachloroethene)	127-18-4
toluene	108-88-3
1,1,1-trichloroethane (methylchloroform)	71-55-6
1,1,2-trichloroethane	79-00-5
trichloroethylene (trichloroethene)	79-01-6
trichlorofluoromethane(CFC-11)	75-69-4
1,2,3-trichloropropane	96-18-4
vinyl acetate	108-05-4
vinyl chloride	75-01-4
xylenes (total)	1330-20-7



## **Attachment C**

### **TDH Lab Practical Quantitation Limits for Table 1 VOCs**





## Attachment C

### TDH Lab Practical Quantitation Limits for Table 1 VOCs

Parameter	CAS No.	*PQL, μg/L
acetone	67-64-1	<10
acrylonitrile	107-13-1	<10
benzene	71-43-2	<2
bromochloromethane	74-97-5	<2
bromodichloromethane	75-27-4	<2
bromoform (tribromomethane)	75-25-2	<2
carbon disulfide	75-15-0	<2
carbon tetrachloride	56-23-5	<2
chlorobenzene	108-90-7	<2
chloroethane (ethyl chloride)	75-00-3	<5
chloroform (trichloromethane)	67-66-3	<2
dibromochloromethane (chlorodibromomethane)	124-48-1	<2
1,2-dibromo-3-chloropropane (DBCP)	96-12-8	<2
1,2-dibromoethane (ethylene dibromide, EDB)	106-93-4	<2
o-dichlorobenzene (1,2-dichlorobenzene)	95-50-1	<2
p-dichlorobenzene (1,4-dichlorobenzene)	106-46-7	<2
trans-1,4-dichloro-2-butene	110-57-6	<20
1,1-dichloroethane (ethylidene chloride)	75-34-3	<2
1,2-dichloroethane (ethylene dichloride)	107-06-2	<2
1,1-dichloroethylene (1,1-dichloroethene)	75-35-4	<2
cis-1,2-dichloroethylene (cis-1,2-dichloroethene)	156-59-2	<2
trans-1,2-dichloroethylene (trans-1,2-dichloroethene)	156-60-5	<2
1,2-dichloropropane (propylene dichloride)	78-87-5	<2
cis-1,3-dichloropropene	10061-01-5	<2
trans-1,3-dichloropropene	10061-02-6	<2
ethylbenzene	100-41-4	<2
2-hexanone (methyl butyl ketone)	591-78-6	<2
methyl bromide (bromomethane)	74-83-9	<5
methyl chloride (chloromethane)	74-87-3	<5
methylene bromide (dibromomethane)	74-95-3	<2
methylene chloride (dichloromethane)	75-09-2	<2
methyl ethyl ketone (MEK, 2-butanone)	78-93-3	<10
methyl iodide (iodomethane)	74-88-4	<2
4-methyl-2-pentanone (methyl isobutyl ketone)	108-10-1	<2
styrene	100-42-5	<2
1,1,1,2-tetrachloroethane	630-20-6	<2
1,1,2,2-tetrachloroethane	79-34-5	<2
tetrachloroethylene (tetrachloroethene)	127-18-4	<2
toluene	108-88-3	<2
1,1,1-trichloroethane (methylchloroform)	71-55-6	<2
1,1,2-trichloroethane	79-00-5	<2
trichloroethylene (trichloroethene)	79-01-6	<2
trichlorofluoromethane (CFC-11)	75-69-4	<2
1,2,3-trichloropropane	96-18-4	<2
vinyl acetate	108-05-4	<10
vinyl chloride	75-01-4	<2
xylene (total)	1330-20-7	<6

\*PQL = practical quantitation limits.



## **Attachment D**

### **TNRCC 0312 Ground-Water Sampling Report**



**TEXAS NATURAL RESOURCE CONSERVATION COMMISSION**  
**MUNICIPAL SOLID WASTE DIVISION**  
**Ground-Water Sampling Report**

Site name \_\_\_\_\_ MSW permit no. \_\_\_\_\_

Permittee \_\_\_\_\_ Monitor well no. \_\_\_\_\_

County \_\_\_\_\_ Installation date \_\_\_\_\_

Date of water level measurements \_\_\_\_\_

Integrity of well \_\_\_\_\_

Datum reference point \_\_\_\_\_ Datum elevation\* \_\_\_\_\_

Depth to water (below datum)\* \_\_\_\_\_ Water level elevation\* \_\_\_\_\_

Bailing or pumping method \_\_\_\_\_ Well volumes purged \_\_\_\_\_

Was the well dry before purging? \_\_\_\_\_ After? \_\_\_\_\_

How long before sampling? \_\_\_\_\_ hrs

Most recent previous date of sampling \_\_\_\_\_

GWSAP schedule requirements (SDP):

☐ Background      ☐ Semi-annual      ☐ Annual      ☐ Quarterly

Date of sampling \_\_\_\_\_ Name of sampler \_\_\_\_\_

Affiliation of sampler \_\_\_\_\_

If split-sampled, with whom? \_\_\_\_\_

Field measurements: pH \_\_\_\_; Spec. cond. \_\_\_\_  $\mu\text{mho/cm}$ ; Temp. \_\_\_\_  $^{\circ}\text{F}/^{\circ}\text{C}$

Laboratory Name \_\_\_\_\_ Phone \_\_\_\_\_

Laboratory Address \_\_\_\_\_

Laboratory Representative's Signature \_\_\_\_\_

Site operator's signature \_\_\_\_\_ Date \_\_\_\_\_

\* Report depth to water and elevations to nearest 0.01 foot relative to mean sea level (MSL).



TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

MUNICIPAL SOLID WASTE DIVISION

Ground-Water Sampling Report, p. 2

HEAVY METALS

<u>Constituent</u>			<u>Concentration</u>	<u>Reporting Limits***</u>	<u>Method</u>
Antimony	*T	**D	_____ µg/l	_____ µg/l	_____
Arsenic	T	D	_____ µg/l	_____ µg/l	_____
Barium	T	D	_____ µg/l	_____ µg/l	_____
Beryllium	T	D	_____ µg/l	_____ µg/l	_____
Cadmium	T	D	_____ µg/l	_____ µg/l	_____
Chromium	T	D	_____ µg/l	_____ µg/l	_____
Cobalt	T	D	_____ µg/l	_____ µg/l	_____
Copper	T	D	_____ µg/l	_____ µg/l	_____
Lead	T	D	_____ µg/l	_____ µg/l	_____
Mercury	T	D	_____ µg/l	_____ µg/l	_____
Nickel	T	D	_____ µg/l	_____ µg/l	_____
Selenium	T	D	_____ µg/l	_____ µg/l	_____
Silver	T	D	_____ µg/l	_____ µg/l	_____
Thallium	T	D	_____ µg/l	_____ µg/l	_____
Vanadium	T	D	_____ µg/l	_____ µg/l	_____
Zinc	T	D	_____ µg/l	_____ µg/l	_____
Iron	T	D	_____ µg/l	_____ µg/l	_____
Manganese	T	D	_____ µg/l	_____ µg/l	_____

\*Total or \*\*Dissolved (circle appropriate type); use two pages if both are run.

\*\*\*Indicate if reporting limits are \_\_\_\_\_ PQLs or \_\_\_\_\_ MDLs.





**TEXAS NATURAL RESOURCE CONSERVATION COMMISSION**  
**MUNICIPAL SOLID WASTE DIVISION**  
**Ground-Water Sampling Report, p. 3**

**VOLATILE ORGANIC COMPOUNDS (VOCs)**

CONSTITUENT	CONCENTRATION, µg/l	*REPORTING LIMITS, µg/l	METHOD	CAS NO.
acetone				67-64-1
acrylonitrile				107-13-1
benzene				71-43-2
bromochloromethane				74-97-5
bromodichloromethane				75-27-4
bromoform				75-25-2
carbon disulfide				75-15-0
carbon tetrachloride				56-23-5
chlorobenzene				108-90-7
chloroethane				75-00-3
chloroform				67-66-3
dibromochloromethane				124-48-1
1, 2-dibromo-3-chloropropane				96-12-8
1, 2-dibromoethane				106-93-4
o-dichlorobenzene (1, 2)				95-50-1
p-dichlorobenzene (1, 4)				106-46-7
trans-1, 4-dichloro-2-butene				110-57-6
1, 1-dichloroethane				75-34-3
1, 2-dichloroethane				107-06-2
1, 1-dichloroethylene				75-35-4
cis-1, 2-dichloroethylene				156-59-2
trans-1, 2-dichloroethylene				156-60-5
1, 2-dichloropropane				78-87-5
cis-1, 3-dichloropropene				10061-01-5
trans-1, 3-dichloropropene				10061-02-6
ethylbenzene				100-41-4
2-hexanone				591-78-6
methyl bromide				74-83-9
methyl chloride				74-87-3
methylene bromide				74-95-3
methylene chloride				75-09-2
methyl ethyl ketone				78-93-3
methyl iodide				74-88-4
4-methyl-2-pentanone				108-10-1
styrene				100-42-5
1, 1, 1, 2-tetrachloroethane				630-20-6
1, 1, 2, 2-tetrachloroethane				79-34-5
tetrachloroethylene				127-18-4
toluene				108-88-3
1, 1, 1-trichloroethane				71-55-6
1, 1, 2-trichloroethane				79-00-5
trichloroethylene				79-01-6
trichlorofluoromethane				75-69-4
1, 2, 3-trichloropropane				96-18-4
vinyl acetate				108-05-4
vinyl chloride				75-01-4
xylene (total)				1330-20-7

\*Indicate if reporting limits are \_\_\_\_\_ PQLs or \_\_\_\_\_ MDLs.



TEXAS NATURAL RESOURCE CONSERVATION COMMISSION  
MUNICIPAL SOLID WASTE DIVISION  
Ground-Water Sampling Report, p. 4

OTHER PARAMETERS

PARAMETER	CONCENTRATION	REPORTING LIMITS*	METHOD

\* Indicate if reporting limits are \_\_\_\_\_PQLs or \_\_\_\_\_ MDLs.  
Indicte if each analysis is for the total (T) or dissolved (D) constituent.  
Show units of concentration and reporting limits.



## **Attachment E**

### **Drinking Water Standards – Phases II and V**







April 29, 1994

## **DRINKING WATER STANDARDS – PHASES II AND V**

*This fact sheet summarizes many of the changes to the Drinking Water Standards for Texas adopted by the Texas Natural Resource Conservation Commission (TNRCC) on March 25, 1994. Most of these changes were made to implement U.S. Environmental Protection Agency Phase II and Phase V rules.*

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### **Maximum Contaminant Levels**

- \* The TNRCC has adopted 59 new or revised maximum contaminant levels (MCLs) for public drinking water (Table 1, 3, 4). Initial monitoring for the newly regulated contaminants began on January 1, 1993.
- \* The TNRCC is also now requiring monitoring for 33 unregulated contaminants (Table 2).

---

### **Monitoring Framework**

- \* Effective January 1, 1993, the sampling for most chemical contaminants in public water supply (PWS) systems follows a standardized framework (Fig. 1).
- \* With the exception of nitrate/nitrite, monitoring for these chemicals is restricted to community and non-transient non-community systems.
- \* TNRCC will notify PWS systems of monitoring requirements during the initial monitoring round (1993-1995). Current plans call for sampling large systems in 1993 (> 3,300 population served), medium systems (500-3,300 population served) in 1994, and small systems (<500 population served) in 1995.

---

### **Waivers**

- \* With the exception of nitrate and nitrite, sampling waivers may be issued by the TNRCC for many of the inorganic and organic chemicals. These waivers are based on one or more of the following: (1) prior monitoring by the Texas Department of Health (TDH) / Texas Water Commission (TWC), (2) past use or occurrence of the



contaminant in the zone of contribution for the water source, (3) a vulnerability assessment of the water source.

- \* TNRCC will issue the maximum number of technically defensible waivers for sampling of Phase II & V contaminants during the initial monitoring round. Applications for these waivers are not required; the TNRCC will evaluate all PWS systems. Most waivers will be for a three-year period, except inorganic chemicals, which may receive waivers for up to nine years.
- \* A PWS system will significantly enhance its probability of receiving waivers by providing complete and accurate information to TNRCC upon request. This information includes documentation of well construction, geological well logs, evidence of TDH or TWC approval of well construction, the extent of asbestos/cement pipe in the distribution system, and the pH and alkalinity of treated water at each entry point into the distribution system.
- \* Waivers for all eligible Phase II & V contaminants could save a PWS system up to \$9,000 per sampling point during the initial round of monitoring.

---

## **Sampling**

- \* Monitoring samples will be taken by TNRCC Regional Inspectors at entry points of new treated water into the distribution system rather than at service connection taps.
- \* Field compositing of inorganic samples are at the discretion of the Regional Inspector. Compositing of samples for organic contaminants is only allowed in the laboratory, and is not being done by TDH because of limited storage space.
- \* Confirmation samples will be required when MCLs are exceeded. Quarterly sampling will be required if the confirmation sample verifies a MCL violation.
- \* Detections of a regulated organic chemical will trigger a quarterly sampling requirement for that contaminant. Detection limits for most organic contaminants are close to 0.0005 mg/L.

---

## **Laboratory Analyses**

- \* All monitoring samples must be analyzed by the EPA-certified TDH Bureau of Laboratories in Austin.
- \* Effective January 1, 1993, all PWS systems will be billed directly by TDH for the cost of their water analyses. Costs for these analyses are no longer paid for by the TNRCC fee for services to drinking water systems.

## Enforcement

- \* The rules for Phases II & V require public notifications for MCL violation using specific media (newspaper, television, etc.), health effects language, and within a prescribed time frame.
- \* Use of bottled water or connection to uncontaminated water sources will continue to be the only acceptable short-term solutions for MCL violations.
- \* The TNRCC will enter into bilateral compliance agreements to insure PWS systems establish adequate treatment of contaminated water. Long-term treatment must utilize the Best Available Technology (BAT) specified in the revised Texas Drinking Water Standards.

First 9-year Compliance Cycle	1993	Initial Monitoring Round
	1994	
	1995	
	1996	Repeat Monitoring
	1997	
	1998	
	1999	Repeat Monitoring
	2000	
	2001	
Begins Second 9-year Cycle	2002	Repeat Monitoring
	2003	
	2004	

Figure 1. Standardized monitoring framework for public water supply systems.

Table 1. Organic Chemicals - Maximum Contaminant Levels<sup>1</sup>

<u>Contaminant</u>	<u>mg/l</u>	<u>Constituent</u>	<u>mg/l</u>
<i>Alachlor</i>	<i>0.002</i>	<i>Ethylbenzene</i>	<i>0.7</i>
<i>Aldicarb</i>	<i>0.003</i>	<i>Ethylene Dibromide (EDB)</i>	<i>0.00005</i>
<i>Aldicarb sulfone</i>	<i>0.002</i>	<i>Glyphosate</i>	<i>0.7</i>
<i>Aldicarb sulfoxide</i>	<i>0.004</i>	<i>Heptachlor</i>	<i>0.0004</i>
<i>Atrazine</i>	<i>0.003</i>	<i>Heptachlor Epoxide</i>	<i>0.0002</i>
Benzene	0.005	<i>Hexachlorobenzene</i>	<i>0.001</i>
<i>Benzo(a)pyrene</i>	<i>0.0002</i>	<i>Hexachlorocyclopentadiene</i>	<i>0.05</i>
<i>Carbofuran</i>	<i>0.04</i>	<i>Lindane</i>	<i>0.0002</i>
Carbon Tetrachloride	0.005	<i>Methoxychlor</i>	<i>0.04</i>
<i>Chlordane</i>	<i>0.002</i>	<i>Monochlorobenzene</i>	<i>0.1</i>
<i>2,4-D</i>	<i>0.07</i>	<i>Oxamyl (Vydate)</i>	<i>0.2</i>
<i>Dalapon</i>	<i>0.2</i>	<i>Pentachlorophenol</i>	<i>0.001</i>
<i>Dibromochloropropane (DBCP)</i>	<i>0.0002</i>	<i>Picloram</i>	<i>0.5</i>
<i>Di(2-ethylhexyl)adipate</i>	<i>0.4</i>	<i>Polychlorinated Biphenyls (PCB)</i>	<i>0.0005</i>
<i>Di(2-ethylhexyl)phthalate</i>	<i>0.006</i>	<i>Simazine</i>	<i>0.004</i>
<i>o-Dichlorobenzene</i>	<i>0.6</i>	<i>Styrene</i>	<i>0.1</i>
p-Dichlorobenzene	0.075	<i>2,3,7,8-TCDD (Dioxin)</i>	<i>0.00000003</i>
1,2-Dichloroethane	0.005	<i>Tetrachloroethylene</i>	<i>0.005</i>
1,1-Dichloroethylene	0.007	<i>Toluene</i>	<i>1.0</i>
<i>cis-1,2-Dichloroethylene</i>	<i>0.07</i>	Toxaphene	0.003
<i>trans-1,2-Dichloroethylene</i>	<i>0.1</i>	<i>2,4,5-TP (Silvex)</i>	<i>0.05</i>
<i>Dichloromethane</i>	<i>0.005</i>	<i>1,2,4-Trichlorobenzene</i>	<i>0.07</i>
<i>1,2-Dichloropropane</i>	<i>0.005</i>	1,1,1-Trichloroethane	0.2
<i>Dinoseb</i>	<i>0.007</i>	<i>1,1,2-Trichloroethane</i>	<i>0.005</i>
<i>Diquat</i>	<i>0.02</i>	Trichloroethylene	0.005
<i>Endothall</i>	<i>0.1</i>	<i>Vinyl Chloride</i>	<i>0.002</i>
<i>Endrin</i>	<i>0.002</i>	<i>Xylenes (total)</i>	<i>10.0</i>

<sup>1</sup> Bold values in italics indicate new or revised maximum contaminant levels.

Table 2. Organic Chemicals - Monitoring Only

Aldrin	Chloromethane	Dichlorodifluoromethane
Bromobenzene	o-Chlorotoluene	Dieldrin
Bromochloromethane	p-Chlorotoluene	Fluorotrichloromethane
Bromodichloromethane	Dibromomethane	3-Hydroxycarbofuran
Bromoform	Dicamba	Methomyl
Bromomethane	m-Dichlorobenzene	Metolachlor
Butachlor	1,1-Dichloroethane	Metribuzin
Carbaryl	1,3-Dichloropropane	Propachlor
Chlorodibromomethane	2,2-Dichloropropane	1,1,1,2-Tetrachloroethane
Chloroethane	1,1-Dichloropropene	1,1,2,2-Tetrachloroethane
Chloroform	1,3-Dichloropropene	

1,2,3-Trichloropropane

Table 3. Inorganic Chemicals - Maximum Contaminant Levels<sup>1</sup>

<u>Contaminant</u>	<u>mg/l</u>	<u>Applicable Systems</u> <sup>2</sup>
<b>Antimony</b>	<b>0.006</b>	<b>CN</b>
Arsenic	0.05	CN
<b>Asbestos</b>	<b>7 million fibers/liter (longer than 10<math>\mu</math>m)</b>	<b>CN</b>
<b>Barium</b>	<b>2.0</b>	<b>CN</b>
<b>Beryllium</b>	<b>0.004</b>	<b>CN</b>
<b>Cadmium</b>	<b>0.005</b>	<b>CN</b>
<b>Chromium</b>	<b>0.1</b>	<b>CN</b>
<b>Cyanide</b>	<b>0.2 (as free cyanide)</b>	<b>CN</b>
Fluoride	4.0	C
Mercury	0.002	CN
<b>Nickel</b>	<b>0.1</b>	<b>CN</b>
Nitrate	10.0 (as nitrogen)	CNT
<b>Nitrite</b>	<b>1.0 (as nitrogen)</b>	<b>CNT</b>
<b>Nitrate + Nitrite (Total)</b>	<b>10.0 (as nitrogen)</b>	<b>CNT</b>
<b>Selenium</b>	<b>0.05</b>	<b>CN</b>
<b>Thallium</b>	<b>0.002</b>	<b>CN</b>

Table 4. Secondary Maximum Contaminant Levels<sup>1</sup>

<u>Contaminant</u>	<u>Level</u> <sup>3</sup>
<b>Aluminum</b>	<b>0.05 to 0.2 mg/L</b> <sup>4</sup>
Chloride	300 mg/l
Color	15 color units
Copper	1.0 mg/l
Corrosivity	Non-corrosive
Fluoride	2.0 mg/l
Foaming agents	0.5 mg/l
Hydrogen sulfide	0.05 mg/l
Iron	0.3 mg/l
Manganese	0.05 mg/l
Odor	3 Threshold Odor Number
pH	$\geq 7.0$
<b>Silver</b>	<b>0.10 mg/l</b>
Sulfate	300 mg/l
Total dissolved solids (TDS)	1000 mg/l
Zinc	5.0 mg/l

<sup>1</sup> Bold values in italics indicate new or revised maximum contaminant levels.

<sup>2</sup> C = Community; N = Non-transient, non-community; T = Transient, non-community.

<sup>3</sup> With the exception of the fluoride MCL, which applies only to community public water supply systems, these apply to both community and noncommunity systems.

<sup>4</sup> Range of values is based on aesthetic considerations and not on known health effects.